

EXHIBIT 2

(12) **United States Patent**
Blumenthal et al.

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(54) **SYSTEM AND METHOD FOR ADAPTIVE SCALABLE DYNAMIC CONVERSION, QUALITY AND PROCESSING OPTIMIZATION, ENHANCEMENT, CORRECTION, MASTERING, AND OTHER ADVANTAGEOUS PROCESSING OF THREE DIMENSIONAL MEDIA CONTENT**

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G06T 15/00 (2011.01)
G06G 5/00 (2006.01)

(52) **U.S. Cl.**
USPC **345/419; 345/581; 345/619**

(58) **Field of Classification Search**
USPC **345/419, 581, 619**
See application file for complete search history.

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(57) **ABSTRACT**

In at least one embodiment thereof, the inventive system and method are directed to providing and configuring a novel platform-independent 3D content media container operable to: (1) support and store a 3D content media file with at least one 3D content modification/improvement technique applied to only specific predetermined portions thereof, and (2) selectively enabling particular optimal 3D content-related parameter settings for future application of at least one additional 3D content modification/improvement technique, to likewise be associated with one or more specific corresponding 3D content media file portion(s), and to also be stored in association therewith in the inventive 3D content media container. In at least one additional embodiment thereof, the inventive system and method are capable of determining and implementing various storage, transmittal, and application(s) of 3D content media processing/settings/parameter/profile configuration(s) prior to, or during, display of corresponding 3D content media.

19 Claims, 3 Drawing Sheets

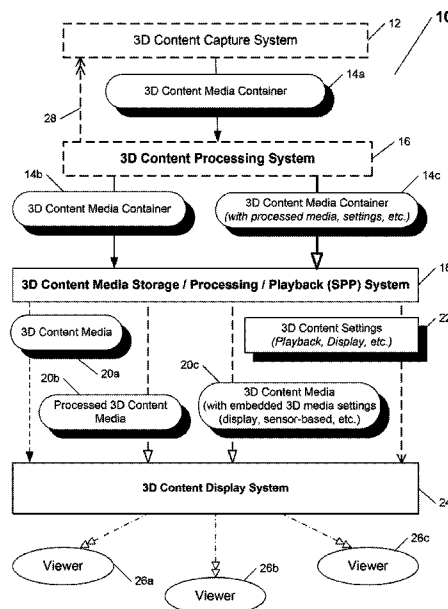


FIG. 1

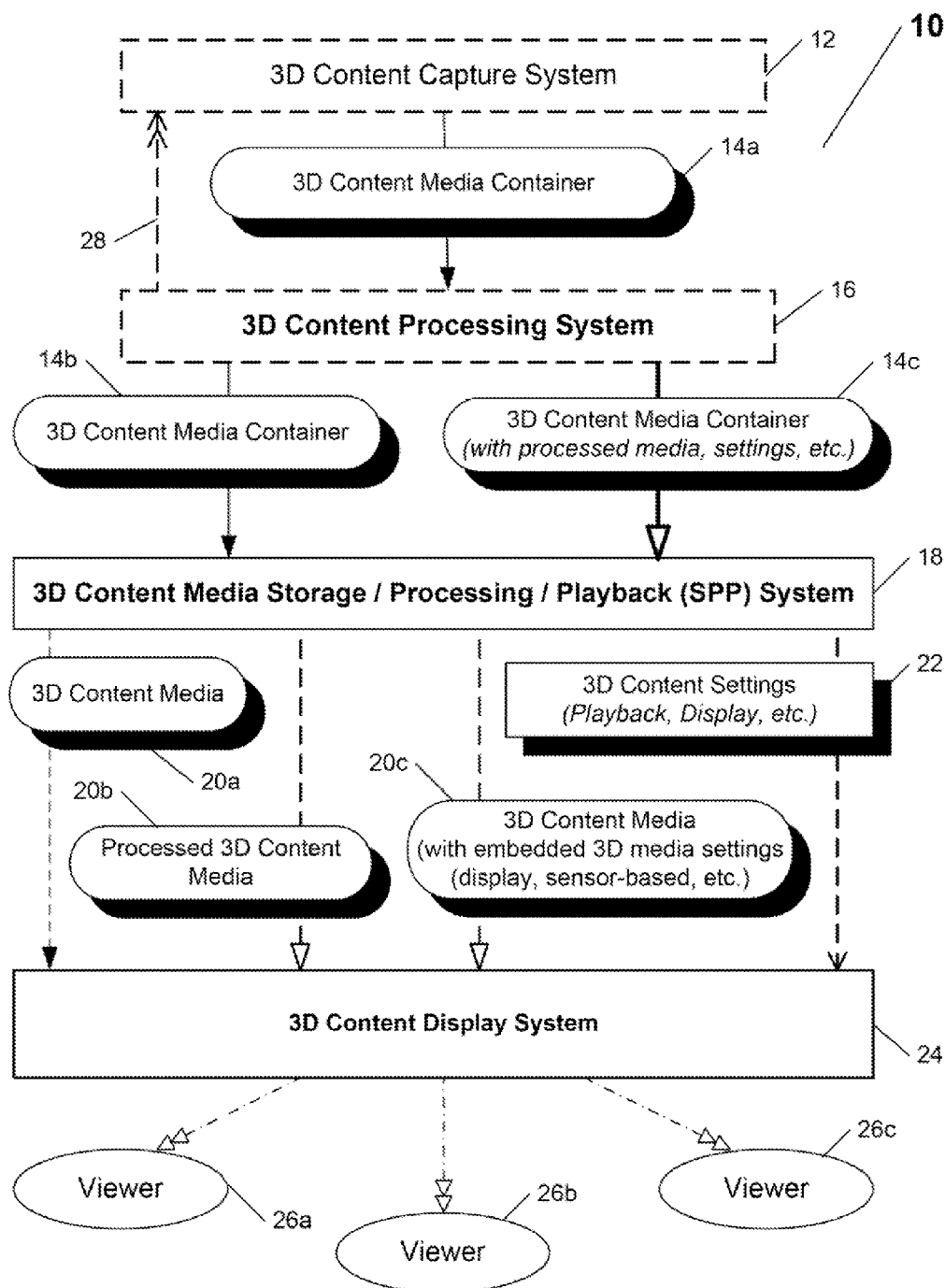


FIG. 2

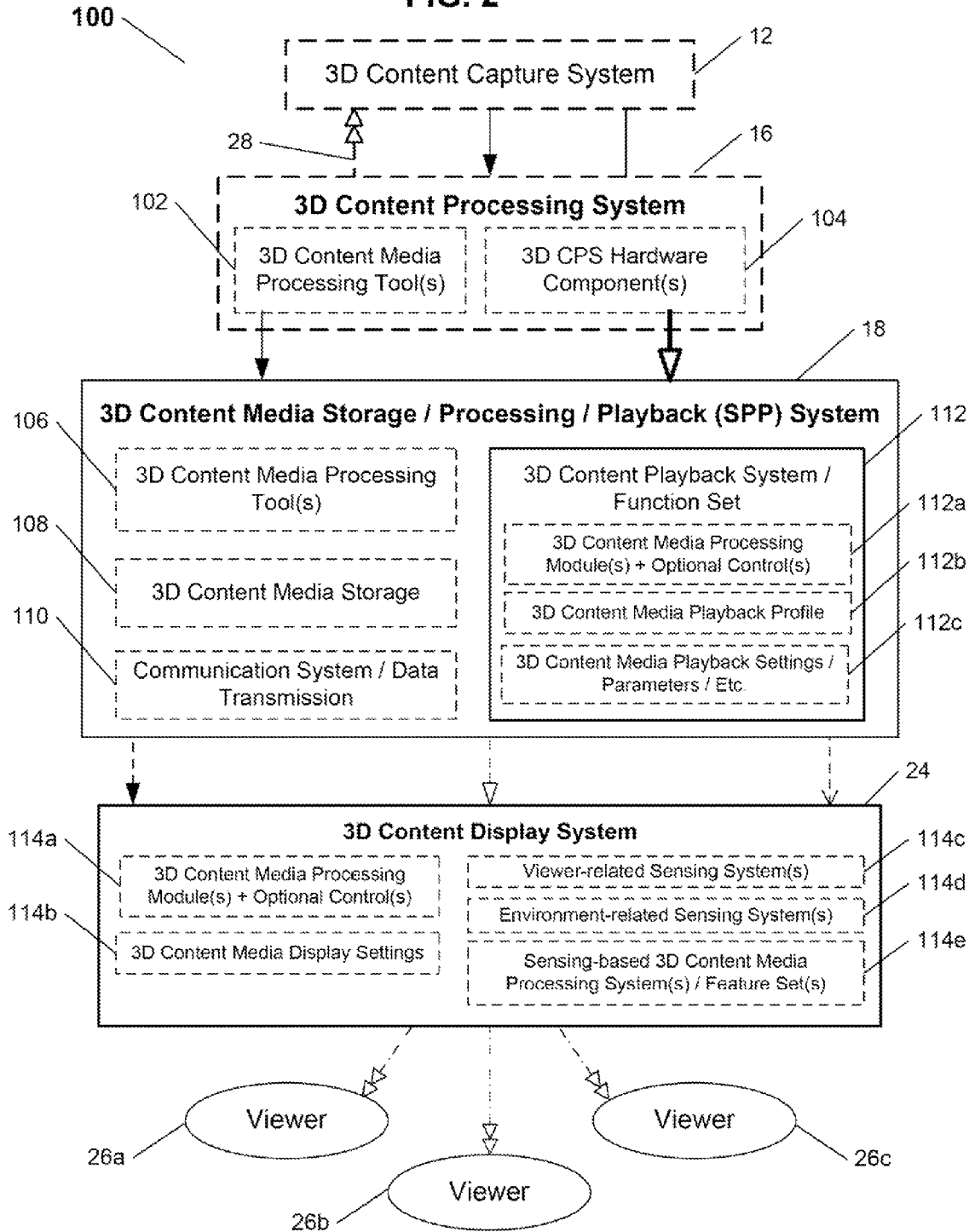
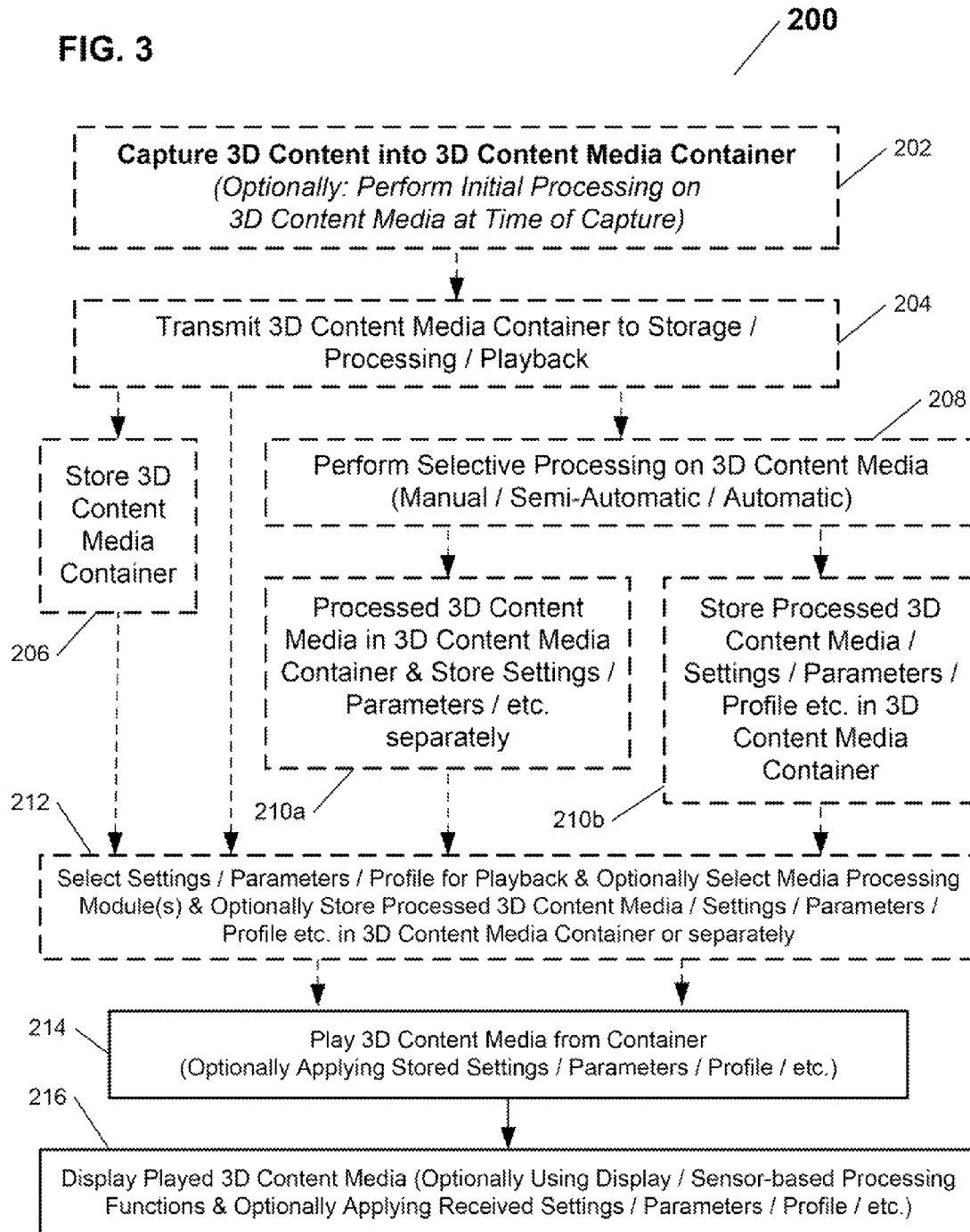


FIG. 3



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**SYSTEM AND METHOD FOR ADAPTIVE
SCALABLE DYNAMIC CONVERSION,
QUALITY AND PROCESSING
OPTIMIZATION, ENHANCEMENT,
CORRECTION, MASTERING, AND OTHER
ADVANTAGEOUS PROCESSING OF THREE
DIMENSIONAL MEDIA CONTENT**

**CROSS REFERENCE TO RELATED
APPLICATION**

The present patent application claims priority from the commonly assigned U.S. provisional patent application 61/138,926 entitled "SYSTEM AND METHOD FOR ADAPTIVE SCALABLE DYNAMIC CONVERSION, QUALITY AND PROCESSING OPTIMIZATION, ENHANCEMENT, CORRECTION, MASTERING, AND OTHER ADVANTAGEOUS PROCESSING OF THREE DIMENSIONAL MEDIA CONTENT", filed Dec. 18, 2008.

FIELD OF THE INVENTION

The present invention relates generally to systems and methods for improving the 3D experience provided by playback and display of 3D media content, and more particularly to systems and methods for providing 3D content media-centric solutions that greatly improve the quality and impact and other desirable features of any 3D media content, while decreasing the required levels of computing power, and lowering the complexity of the necessary 3D media playback and 3D media display solutions, thus maximizing the 3D experience produced therefrom.

BACKGROUND OF THE INVENTION

Various tools for capturing, generating, processing, playing back and displaying three dimensional (3D) content media (especially motion video), have been available for quite some time. Display technologies for 3D content media in particular have evolved quite a bit from the earliest barely passable offerings which required the audience to wear flimsy "glasses" provided with a different (red or blue) lens for each eye, to more advanced electronic "stereoscopic 3D" glasses equipped with remotely triggered liquid crystal display (LCD)-based lenses (acting as alternating individually controlled "shutters"), which provided its wearers with an engaging and quality "3D experience", given properly prepared 3D content media paired with the appropriate playback and corresponding display technologies working on conjunction with the 3D glasses.

However, this approach for providing a "3D experience" is quite cumbersome and very expensive to use and maintain, and has thus been of very limited commercial success, primarily being relegated to special entertainment venues, such as certain IMAX theaters and high-end amusement parks. In addition to expensive, and relatively fragile, glasses being required for each member of the audience (which in some cases excludes those who cannot comfortably wear them), the latest stereoscopic 3D solutions require sophisticated and expensive computer-based components for storing and processing the 3D content, as well as similarly complex and expensive electronic components for displaying the 3D content and remotely controlling the stereoscopic 3D glasses.

Of course, as is expected, the very limited availability and expense of the above 3D content media playback and display technologies, in particular, have led to a relative lack of interesting 3D content (due to the expense in its creation and the

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very limited commercial interest therein), which in turn has resulted in a very limited availability of 3D content capture and processing tools, thus essentially resulting in a "vicious cycle".

5 Nonetheless, in recent years, there has been a revolutionary leap in the solutions being offered for displaying 3D content media. Specifically, a number of companies, have developed and offered flat panel displays of varying sizes capable of creating a virtual 3D experience for the viewer without the need for the viewer to wear electronic or other types glasses or similar devices. Moreover, these displays do not require other specialized equipment and can work with specially configured 3D content that may be stored on, and played back from, conventional readily available computers. And, while these displays are still quite expensive, they are priced within reach of most organizations (and within reach of some consumers), with the price certainly poised to decrease exponentially, commensurate with an increase in production (as has been the case with the HDTV flat panel display market).

20 Therefore, for the past several years, ever since these newest stand-alone 3D ("SA-3D") content media display technologies have become available at relatively reasonable prices, there has been a widespread consensus that proliferation of three-dimensional (3D) content media (both in entertainment and in advertising), as well as of the hardware and software technologies necessary for SA-3D content capture, processing, playback, and display, is inevitable, and that the market for 3D-related technologies will experience explosive growth.

30 Nevertheless, to date there has not been a dramatic push forward that would make the above predictions become reality. One of the main reasons for this aforementioned lack of the expected proliferation of commercially successful SA-3D-related content, software and hardware offerings, is the fact that although these newest SA-3D content media display technologies have a number of very significant advantages over all previously known 3D-related offerings, they also suffer from a number of flaws. Specifically, on the average, the quality and impact of the 3D experience delivered by the available SA-3D solutions is lower than that of conventional high-end glasses-based stereoscopic 3D offerings. Moreover the relative position of each viewer to the SA-3D screen (in terms of vertical and horizontal viewing angles, distance, etc.) has significant impact on that viewer's overall 3D experience when viewing the displayed SA-3D content. Moreover, the existing SA-3D hardware and software solutions for the capture, processing, playback and display of 3D content media have focused on areas of expertise, offer individual and discrete benefits in various narrow aspects of 3D and SA-3D technologies with little or no regard for the offerings of other solution providers, resulting in literally dozens of incompatible proprietary software and hardware products with nothing to tie them together.

It would thus be desirable to provide a system and method directed to one or more modular unifying scalable solutions, preferably implemented in a configurable infrastructure, that greatly improve the quality and impact of any 3D media content, while decreasing the required levels of computing power, and lowering the complexity of the necessary playback and display solutions. It would further be desirable to provide a system and method capable of achieving the above goals by selectively performing 3D content processing and/or settings/parameter configuration at one or more components of the infrastructure from 3D content capture to 3D content media display. It would moreover be desirable to provide a system and method capable of determining and implementing selective or optimal storage, transmittal, and application(s) of

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3D content processing/settings parameter/profile configuration(s) prior to display of corresponding 3D content media to one or more viewers thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like reference characters denote corresponding or similar elements throughout the various figures:

FIG. 1 is a schematic block diagram of an exemplary embodiment of the inventive scalable modular infrastructure for selectively implementing, configuring, and managing various components of the inventive system for selectively providing adaptive scalable modular functions related to 3D content media capture, generation, quality/processing optimization, enhancement, correction, mastering, and other advantageous processing and/or configuration;

FIG. 2 is a schematic block diagram of exemplary embodiments of various components of the inventive system for selectively providing adaptive scalable modular functions related to 3D content media capture, generation, quality/processing optimization, enhancement, correction, mastering, and other advantageous processing and/or configuration, that may be implemented in the novel infrastructure of FIG. 1; and

FIG. 3 is a process flow diagram of an exemplary embodiment of the inventive process, that may be performed in whole, or selectively in part, by at least one component of the inventive system of FIG. 2, or that may otherwise be implemented in one or more components of the novel infrastructure of FIG. 1.

SUMMARY OF THE INVENTION

The present invention is directed to a system and method for providing 3D content-centric solutions that greatly improve the quality and impact of 3D media content, while decreasing the required levels of computing power, and lowering the complexity of the necessary 3D media playback and display solutions, thus maximizing the 3D experience produced therefrom. The novel system and method accomplish these goals by providing modular unifying scalable 3D content-centered solutions, preferably implemented in a configurable infrastructure, that improve the quality and impact of any 3D media content, while decreasing the required levels of computing power, and lowering the complexity of the necessary playback and display solutions.

The inventive system and method advantageously enable automatic, semi-automatic or user-controlled selective performance of 3D content processing and/or settings/parameter configuration at one or more components of the infrastructure (from 3D content capture, to 3D content processing (and/or 2D to 3D content conversion), and to 3D content media display), and in at least one embodiment thereof, the inventive system and method are capable of determining and implementing selective or optimal storage, transmittal, and application of 3D content processing/settings/parameter/profile configuration(s) prior to, or during, display of corresponding 3D content media to one or more viewers thereof.

Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims.

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DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The system and method of the present invention, address all of the disadvantages, flaws and drawbacks of all previously known 3D-related hardware and software offerings, by providing novel 3D content media-centric solutions that greatly improve the quality and impact of any 3D media content, while advantageously decreasing the required levels of computing power, and lowering the complexity of the necessary 3D media playback and 3D media display solutions, thus maximizing the 3D experience produced therefrom for one or more viewers.

The novel system and method accomplish the above goals by providing modular unifying scalable 3D content-centered solutions, preferably implemented in a configurable infrastructure, that greatly improve the quality and impact of any 3D media content, while decreasing the required levels of computing power, and lowering the complexity of the necessary playback and display solutions.

In various exemplary embodiments thereof, the inventive system and method advantageously enable automatic, semi-automatic or user-controlled selective performance of 3D content processing and/or settings/parameter configuration at one or more components of the infrastructure (from 3D content capture to 3D content media display), and in at least one embodiment thereof, the inventive system and method are capable of determining and implementing selective or optimal storage, transmittal, and application(s) of 3D content processing/settings/parameter/profile configuration(s) prior to display of corresponding 3D content media to one or more viewers thereof.

It should be noted that current 3D media content capture, processing, playback and display solutions take the “lowest common denominator” approach to applying playback/display optimization and related settings (intended to improve the appearance, quality, impact and overall “3-D Experience”) to the 3D content media being displayed to at least one viewer thereof. This is very problematic because the desirable settings and parameters, as well as the necessary processing power and other requirements, for optimizing and maximizing the quality, impact and overall 3-D experience level for any displayed 3D media content, vary greatly between different 3D content media files, and even between different segments/portions within any particular 3D content media file itself. In particular, these variations largely depend on the specific 3D scenes being shown (i.e., on the depicted objects/subjects, their relative motion, complexity, backgrounds, lighting, etc.), and on other external factors, such as the original 3D content capture and/or conversion parameter settings, the capture hardware used, the current display, and even on the viewers’ relative position (orientation, elevation, distance, etc.) thereto.

Finally, prior to discussing the various embodiments of the present invention in greater detail below, it is important to note that while many of the embodiments of the present invention (and the various novel tools, techniques and processes relating thereto), are described and discussed as being implemented and/or utilized in the field of 3D visual entertainment (film, television, games, etc., all embodiments of the inventive system and method, can be readily and advantageously utilized in virtually any scientific, military, medical, forensic, or industrial application based on, or involving 3D visualization or display and/or manipulation of 3D content medial, as a matter of design choice, without departing from the spirit of the invention.

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Referring now to FIG. 1, an exemplary embodiment is shown of an inventive scalable modular infrastructure **10** for selectively implementing, configuring, and managing various components of the inventive system for selectively providing adaptive scalable modular functions related to 3D content media capture, generation, quality/processing optimization, enhancement, correction, mastering, and other advantageous processing and/or configuration.

The infrastructure **10** includes optional components **12** and **16** (3D content capture system **12**, and 3D content processing system **16**) for selectively capturing and optionally processing 3D content media prior to placing it into a 3D content media container (e.g., file, stream, etc.). The infrastructure **10** also includes a 3D content media storage/processing/playback SPP system **18**, operable to selectively store, process, and/or play back 3D content media from a medial container that may be received from components **12** and/or **16**, or that may be delivered from another 3D content media source (such as media converted from another 3D format, or from non-3D content source).

The SPP system **18** preferably communicates with a 3D content display system **24**, operable to display 3D content media (in one or more configurations, and capable of displaying/utilizing at least one of: unprocessed 3D content media **20a**, processed 3D content media **20b**, optimized 3D content setting for use with other 3D media content received from a source outside of the infrastructure **10**, etc.) to at least one viewer (e.g., to viewers, **26a-26c**).

In at least one embodiment of the present invention, the 3D content processing system **16** may also optionally comprise at least one 3D content processing feature/function that is optimized for utilization in conjunction with the 3D content capture system **12**. For example, in one embodiment of the infrastructure **10**, the 3D content capture system **12** may actually be a conventional or a modified 3D content capture system, that is provided with additional necessary features (such as scene/visual field depth mapping (or equivalent capabilities) to enable dynamic (and optionally “on the fly”) capture of 2D content, plus sufficient depth (and/or related non-image) information that is sufficient to enable the systems **12** and **16** to produce desirable 3D content for delivery to the SPP system **18**. An exemplary embodiment of operation of the infrastructure **10** is discussed in greater detail in conjunction with FIG. 3.

Referring now to FIG. 2, various exemplary embodiments of the possible components of an inventive system **100**, that may be implemented in the inventive infrastructure **10** of FIG. 1, operable to selectively provide adaptive scalable modular functions related to 3D content media capture, generation, quality/processing optimization, enhancement, correction, mastering, and other advantageous processing and/or configuration, that may be implemented in the novel infrastructure **10** of FIG. 1. Preferably, one or more of the components (**12**, **16**, **18**, and **24**), and subcomponents (**102** to **114e**) of the inventive system **100**, are capable of performing one or more steps of an exemplary novel process **200** of FIG. 3.

Referring now to FIG. 3, an exemplary embodiment is shown as a process flow diagram of an exemplary embodiment of the inventive process, with steps **202** to **216**, that may be performed in whole, or selectively in part, by at least one component of the inventive system **100** of FIG. 2, or that may be implemented in one or more components of the novel infrastructure **10** of FIG. 1.

In summary, the inventive system **100** (through selective operation of one or more components thereof, as may be implemented in infrastructure **10** of FIG. 1), in additional exemplary embodiments thereof, preferably associates at

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least one predetermined 3D content improvement (“3DCI”) parameter set (optimization, playback, and/or display settings and/or parameters, selection of one or processing modules and/or stages of use thereof (or example during one or more of: capture, post-processing, playback or display), display tool adjustments, etc.), with 3D media content containers.

In at least one embodiment thereof, the optimal 3DCI parameter set comprises a plurality of “static to dynamic” display tools adjustments, which may be advantageously recorded and/or otherwise embedded in the 3D content media file, to thereby become a permanent feature thereof during later playback and/or processing (e.g., post production, etc.) of the 3D content media. In another embodiment of the present invention, the optimal 3DCI parameter set integration technique may also be utilized as a playback feature which is interpreted by a proprietary software and/or hardware 3D media player (which, by way of example can be configured as a “set top box” or equivalent, for 2D to 3D content conversion, playback of “enhanced” 3D content media having an integrated 3DCI parameter set, and for other functions (such as utilization of de-encryption solutions for playback of protected 3D content media).

Advantageously, this association and/or linking, occurs on a scalable basis from the most basic level at which an optimal 3DCI parameter set is associated with one or more corresponding 3D content media containers (that may be in a container directory, a playlist, a queue, or in a similar storage container), such that the appropriate 3DCI parameter set is activated in conjunction with its corresponding 3D content media from the container being played, to a more advanced level at which different 3DCI parameter sets are associated with (or otherwise linked or assigned to), the appropriate different portions of each 3D content media container, such that during playback and/or display thereof, different sections of the displayed content receive the optimal level of “treatment”.

The novel system and method advantageously address and cover both the creation/determination/configuration of various scalable 3DCI parameter sets during 3D content capture, during initial processing, at any other time up to and including on-the-fly during playback, or any combination of the above, as a matter of design choice without departing from the spirit of the invention. Similarly, the process of creation/determination/configuration of the 3DCI parameter sets can be wholly or partially automated, or can be manually performed as a “creative process” by one or more content professional, preferably utilizing one or more 3DCI tools and support modules as desired or as necessary.

For example, tools utilizing novel dynamic and adaptive variable 3D depth and layering techniques of the present invention, may readily be used for both automated and content professional-directed 3DCI parameter creation (e.g., the 3DCI may include desired depth adjustment parameters, variable layer densities centered on certain displayed objects or object types, dynamic variable resolution based on relative distance of the closest object depth layers to the viewer, etc.).

The 3DCI parameter sets may be linked to, or otherwise associated with the respective 3D content media containers (or portions thereof), and may thus be stored in dedicated or other form of files, containers or libraries, separately from the 3D content media containers, or may be stored within the 3D content media containers, (e.g., embedded therein, as discussed above).

The inventive system **100** (through selective operation of one or more components thereof, as may be implemented in infrastructure **10** of FIG. 1, for example in accordance with the process **200**, or otherwise), in various additional exem-

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plary embodiments thereof is operable to provide selective, automatic, or user-controlled dynamic/adaptive/scalable utilization of layered depth measurement/mapping techniques in 3D content media, coupled with techniques for identifying and spatially (3D) tracking static and moving displayed objects in the depth mapped layered scenes to provide the desired optimal level of at least one predefined aspect of 3D content experience. Advantageously, in accordance with the present invention, the novel system **100** preferably comprises sufficient hardware and/or software components and sub-components to provide and utilize one or more of the following advantageous and novel functionalities/techniques which are contemplated by the present invention:

Utilization of existing 3D field depth-detection cameras (and related and/or substantially equivalent hardware) during the 3D content capture/acquisition stage, to acquire a predetermined number of depth layers for the 3D content to form the desired layered “depth field environment” for each 3D content frame/scene, etc., which may be the same depth quantity for the entire container, or which may dynamically, adaptively or selectively vary for different portions of the content.

Assignment of predetermined amounts of layers to various displayed objects in the 3D content being captured and/or converted. Optionally, the assignment process may utilize variable layer density (e.g., depending on relative depth of different parts of the objects). Alternately, an object’s layer density distribution (or profile) may be shifted/adjusted dynamically as the object moves within the depth field.

Determination, tracking and use of at least one variable dynamically determined/adaptive “focal” layer (i.e., everything behind the focal layer needs less detail and less layer density, anything close needs more) for entire scenes, or for portions thereof.

Determination, tracking and/or use of different variable dynamically determined/adaptive “focal object” plural layers assigned to one or more objects in various 3D content scenes, and that can move to different depths depending on relative depth positions of the assigned object, thus enabling variable layer density across objects (essentially providing, to the inventive system **100**, a control protocol for simplified manipulation of an object’s depth layer distribution).

In conjunction with one or more of the various features above, utilization of a mixture of different image resolution magnitudes (pixel density, etc.), and/or optionally of related image processing (anti-aliasing, etc.), for portions of objects/scene regions in an optimized manner (for example, by processing/displaying higher resolutions for those object layers that are closest to the viewer (or that otherwise would benefit from additional detail)).

Optionally, maintaining a selected level of “geospatial accuracy” with external calibration distance points or with internal software reference markers, enables visual depth adjustment to precise geo-spatially accurate images to be accomplished to a degree as may be desired (or necessary) for one or more 3D content applications, up to, and inclusive of, extremely dense layering across each 3D content scene and/or object(s) (for example as may be required for military, scientific, and/or medical applications, etc.).

Utilization\ and/or adaptation of various advantageous geo-centric survey depth (elevation) mapping techniques and methodologies, preferably with additional modifications applied thereto to make them dynamic, adaptive, and highly configurable.

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Selective configuration, implementation, and use of various additional features including, but not limited to: dedicated 3D processing (D3DP) hardware (e.g., “black box”) re-mastering/editing tools, depth correction techniques, various display/media player modules and editing tools, streamlining D3DP hardware rendering conversion processes (e.g., grayscale values to corresponding layer depth locking, and later image depth manipulation/correction/optimization via grayscale value adjustments, etc.), and so forth.

It should also be noted that the various embodiments of the inventive system and method, can be advantageously configured, and/or adapted, to utilize and/or combine the very best of currently available (as well as any future) 3D-related solutions in an interoperable manner, that is as transparent as possible to the end user (whether the user is in the field of 3D content creation, or is part of the 3D content audience).

By way of example, the present invention may be implemented, in whole or in part, in connection with, or utilizing a 2D to 3D video conversion server (3DVC server), utilizing various additional applications and software-based tools. This technique may employ a variety of commercially available software tools designed to provide for some specific 2D to 3D conversion techniques such as separate interval field sequential frame grabbing, and thereafter mixing of the subsequent frames to create a depth map based on horizontal motion (which in itself is a sub-standard 3D conversion technique). However, when this approach, is integrated with a variety of other compatible 3D content enhancement techniques, and further assisted/upgraded by the aforementioned inventive system features and tools, it may be configured and implemented to perform at a substantially higher standard of 3D depth conversion, and therefore become an excellent candidate for an inexpensive and easily to use basis for a Broadcast Quality 3D video standard. It should be noted that the opportunity to integrate a number of commercially available 2D to 3D video depth conversion methodologies with a 3DVC server exists only as a consequence of the implementation of the various novel depth mapping correction and relating techniques of the inventive system **100**.

Therefore, the combination of the various commercially available 3D-related tools in concert with a 3DVC server, a media player, the various novel post-processing and display tools of the present invention, unexpectedly and advantageously resulted in the discovery of a completely unique and new process of image correction, 3D depth mapping, and depth impact optimization, that, when properly used and configured in accordance with the present invention are capable of elevating conventional 2D+Depth 3D media to Broadcast quality.

The various inventive depth mapping solutions and novel techniques, when applied to 3D content media provided by a conventional 3D 3DVC, unexpectedly result in a “remastering” of the 3DVC server, thus constituting an entirely new commercial application of a conventional 3D technology package “fused” with various novel solutions offered by the present invention, and therefore providing a breakthrough opportunity to produce 3D 2D+Depth stereoscopic 3D content media having maximum depth 3D visual impact, but without distracting visual artifacts.

In addition, it should be noted that while a conventional 3DVC server most is most commonly used to convert 2D content to 2D+Depth 3D content, it is also capable of converting dual path stereoscopic optical signals to the 2D+Depth format, and also capable of converting stereoscopic side-by-side and field sequential stereoscopic 3D video, into the 2D+Depth format. Fortunately, the various

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techniques and solutions of the present invention are fully applicable for advantageous utilization in connection with any and all of the aforementioned conversion formats which are supported by the 3DVC server.

Essentially the system and method of the present invention have gone one step further and readily serve as a basis for producing a 3D software solution (that may be optionally augmented with, or replaced by, a hardware component) that is capable of grabbing stereoscopic pairs from a nine multi-view 2D+Depth conversion, and reformatting them back into a side-by-side, or a dual-path conventional 3D signal, for viewing the reformatted 3D content media using stereoscopic 3D glasses. Accordingly, the inventive techniques close the loop and allow the use of a conventional 3DVC server to convert 2D content media not only into a 2D+Depth format, but also automatically into a highly desirable and commercially viable stereoscopic 3D medial content that is necessary for all 3D glasses-based display systems, large and small, thereby enabling a highly demand solution to be offered during the inevitable transition between from 3D glasses-based display systems to ASD systems.

When the above-described combined technology package (hereinafter referred to as a "3DF-3DVC system") is used with conventional and/or novel 3D display tool adjustments and settings, (which, in accordance with the present invention may be readily embedded into a 3D content media file (and optionally recorded/captured "on-the-fly")), the resulting output not only corrects any remaining 3D video image issues/flaws, but will at the same time provide the basis for development and implementation of various guidelines and tools for rapidly effecting a major increase in the impact of the depth perspective visuals in the display of various available and future 3D content media, thus establishing the methodology and infrastructure that is required for widespread production and proliferation of 3D stereoscopic video broadcast quality standards.

For example, various inventive 3DF-3DVC system techniques may be employed in all of 3DVC server applications to effectively upgrade the 3D content media quality through "Re-mastering". When these techniques are applied to pre-converted 2D+Depth, s3D 3D video clips, which are designed for display on conventional commercially available 3D ASD screens, advantageously, the issues of depth error correction, cone double image removal and ghosting artifacts may be corrected and therefore eliminated.

The novel techniques and solutions provided in various embodiments of the inventive system **100**, and referenced above in connection with their advantageous ability to synergistically combine with, and vastly improve, conventional 3D systems and solutions (e.g., 3DVC servers, etc.) are described in greater detail below in connection with various additional exemplary embodiments of the present invention.

The various embodiments of the inventive system **100** of FIG. 2, and of the system operation process **200** of FIG. 3, preferably comprise and rely on a selection of a plurality of novel and proprietary "key guidelines" for selection of the most appropriate content (or portions thereof) for maximum impact and visual effect in 3D. By way of example, ideally, the best 3D stereoscopic video content produced for conversion, is captured with the intent to convert the content to 3D during the storyboard stage. Therefore, it is greatly preferable to capture 3D content media in dual optical path stereoscopic 3D, which can still be vastly improved by the various inventive post-production and 3DF-3DVC server techniques. Various additional key guidelines that may be readily implemented in accordance with the present invention include, but are not limited to, the following:

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The editing process of pre-captured 2D video can make or break the depth impact produced in 3D content media produced through a 2D to 3D conversion process. Therefore, choosing the best video frames for 2D to 3D conversion, is described below as the first step in the editing/post-production/re-mastering process in optimal 3D-3DVC system operations. Specifically:

The best frames for 3D 3DVC server conversion have content that is on the brighter side, with few dark images (where the sense of depth can be easily lost). Therefore, designing the content media so that darker objects and backgrounds are behind brighter objects in the foreground, will maximize the 3D effect.

Content with multiple spatial layers, larger objects and smaller objects creating reference points for depth perspective, will provide richness in texture and lighting effects (e.g., shadows are quite advantageous).

Content which is not fast moving from shot to shot is also preferable. High speed dynamic content does not work well in 3D content media. This is because in stereo 3D the viewer's eyes need time to register the full impact of the image, so slower content motion is better, especially in the case where the content comprises complex action scenes.

Larger objects which hold perspective, such as depth perspective on equipment, large objects, such as buildings, or interior shots in which the perspective is already attempting to simulate 3D, are all advantageous. Any "3D type" shots during which the camera is moving around an object and looking at it from multiple viewpoints, are also excellent.

Content which comprises some objects or actions that are "coming forward" from a rear perspective of the display to the front of the display.

Content in which the background is darker than the foreground, or in which the object is in a high contrast to the background, and moving forward into the foreground facilitates a desirable 3D impact.

Content comprising text graphics that are relatively centered and stationary, as opposed to being in motion (e.g., from left to right, and vice-versa), as well as content comprising text graphics that are centered and moving from the rear of the display to the front of the display are good.

Content in which objects appear smaller in the background, which then move forward into the foreground, while growing in size as they do so, as well as content comprising object perspective shots, are likewise good.

Any content image that is rendered utilizing 3D modeling techniques for a 3D depth effect. All computer generated graphic images, if they are not being displayed at very high speed are good candidates for such conversion.

Content which comprises imagery that moves from the center of the display background to center of the display foreground, avoiding image overlap with the frame of the display, will give a far stronger, the best forward "POP out of the display", effect.

Likewise, the key guidelines also include a number of guidelines relating to identifying poor choices in 3D content media selection. Some examples of the worst types of content candidates for 3D conversion by the 3DF-3DVC server, include, but are not limited to:

Content comprising high speed "jump shots" which are approx 6 seconds or less, from segue to segue.

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Content comprising dark image shots in the foreground, and light image shots with many small moving objects on the display are difficult.

Content comprising Objects traveling from left to right with minimum size change, as well as content comprising multiple objects of the same size and in the same plane, with very little layering, or visual reference points.

Content in which blurred objects are moving away from each other, and objects lacking sharp lines and edges, make it difficult to visually defined masses.

The various embodiments of the inventive system **100** of FIG. 2, and of the system operation process **200** of FIG. 3, also advantageously comprise and rely, on a selection of a plurality of novel and proprietary “guidelines for post/prep 2D editing of 2D content for conversion” that facilitate the selection of the most appropriate techniques, methodologies and/or of parameters used in connection therewith, for achieving the maximum impact and visual effect in 3D:

1) Sharper Edge Detection Preparation: When assembling edited 2D content for conversion to 3D, brightness gain control should be used to step up the brightness level, thereby defining all edges hiding in shadows.

(a) For this editing technique, it is useful to create maximum edge definition using the sharpness control and the contrast control to darken shadows, leaving edges behind. The use of color intensity to accomplish the same definition of edges and masses is also effective. Re-adjustment of contrast and brightness can thereafter be added on the display tool level stage after the 3D conversion process takes place.

2) Fast Action Time corrections: The rule of thumb for this exemplary inventive guideline, is that if a frame count of a clip of content media is less than 100 frames over 3 seconds, then 3D conversion is pointless. The visual detail for such content becomes too fast for the eye to register depth. The solution to dealing with such troublesome content is to either add frames to the pre-edited 2D “fast action shots” by duplication, or by recording the objects in slow motion at the highest resolution possible, or by slowing down the playback of the content media and utilizing any and all available editing tools to correct blurred edges, shadows without objects, and low focus moving elements (which blend into other objects due to poor video/film quality). Likewise, “speed jump shots” are among the worst candidates for conversion to 3D

(a) The only effective option is to treat the wide variety of multiple “objects in fast action” content shots, as one large object, to only define the depth map in terms of two or three levels of depth, and to paint the objects without detail. As an alternative, maximum contrast, going from white foreground to gray side edges to black background may be used, treating every object in the scene in the same manner (the faster the scene, the fewer the contrasting depth map relationships).

(b) Another novel technique that may be advantageously used to slow down an undesirably fast moving image, is to locate elements in high speed action shots which lend themselves to CGI content additions—it is sometimes possible to create a CGI insert edit with a number of frames which will be “new” content, and which are specifically designed to dramatize an existing scene with an additional 3D depth object in the image, with the purpose of creating a specific frame enhanced depth perspective.

3) Opening 3D impact is the most important image of the clip, and therefore it is very advisable to ensure that the 3D

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impact increases over the first 20 seconds, or few minutes of a 3D content media clip, giving the audience a chance to adjust their vision from 2D film to 3D content. It is also advantageous to script objects moving out of the display in the opening scenes of the content, and to ensure that all or most titles and graphics are rendered in 3D motion CGI (or equivalent) and not presented as 2D static images.

4) 3D Visual Rest spots: the time frame of a continuous display of depth intensive images should pre stage the dramatic, most intense elements of the story line. It is advantageous to use 3D depth perspective to create realism, which enhances the power and the significance of the story, the action and the drama. The counterpoint to this is also true in that lowering the 3D impact after the momentary high point in the story line, allows the audience to experience the previous images intensity and recover before the next onslaught.

(a) Consequently there is a real need to create visual realism “highs” as well as “rests periods” to allow the intensity of the 3D content to be properly absorbed and processed by the viewers and contrasted to the imagery in the “rest” spots.

5) Use of camera angles. Use of normal videographic camera angles, close-ups, slow pans, and other conventional film techniques, allows the full detail of a scene to comes into focus. A greater level of detail leads to a higher quality conversion, and a corresponding greater degrees of perceived 3D depth realism and depth impact. It should be noted that 3D depth images are able to offer a variety of special effects in support of a story, or they can take the place of fast action shots, providing depth stimulus, as a substitute for dramatic action.

The various embodiments of the inventive system **100** of FIG. 2, and of the system operation process **200** of FIG. 3, further advantageously comprise and rely, on a selection of a plurality of novel and proprietary “guidelines for 3DF-3DVC system time editing and related techniques” that facilitate the selection of the most appropriate time line editing and related techniques, methodologies and/or of parameters used in connection therewith, for facilitating the maximum possible impact and visual effect in 3D content media.

There are many levels of 3D depth image impact, ranging from a classic “pop out of the display” major impact, in which the depth is the story, to a “depth window” where everything is three dimensional from the display surface backwards, and in which depth appears to be secondary to the story.

A third, and more subtle depth impact, which mimics realism, exists as a balance between the above two extreme effects, and advantageously offers an undercurrent of richness which supports the story line, while enhancing it by making the images so convincing, that the viewer is barely able to maintain their objectivity, or actually loses it—it the ultimate achievement for a 3D special effects to manipulate the viewer, without the viewer’s realization. The process of guiding the viewer into this desirable “depth realism frame of mind” has undergone extensive scientific research and study, as is often referred to by the term “3D Presence”.

The following exemplary novel and proprietary techniques that may be readily implemented in, and utilized using the inventive system **200**, are designed not only to enhance the depth map of the 3D content media image quality per se, but to also provide a framework of techniques which are designed to “seduce” the viewer into an involuntary loss of objectivity with respect to their viewership of the specially edited/processed 3D content. To accomplish this goal, the depth perspective in various scenes must be as self evident as possible—if the viewer is “hunting” for the 3D effect, then this

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technique has failed. The following inventive techniques, referred to above, may be used to produce desirable and advantageous “Depth special effects”:

- 1) The first key step is to produce 3D content media that is free of all video artifacts causing any physical discomfort such as eye strain, dizziness, headaches etc. This leads directly to the need for all 3D stereoscopic images to perform at traditional 2D level of broadcast standards (This is the focus of the first group of the above-described inventive techniques, relating to 3D depth map correction.
- 2) One of the keys to creating broadcast quality 2D to 3D conversion images is to be able to address the depth spatial relationships in each frame in a manner which builds continuity of depth mapping, so that following frames are building the same depth relationships within the eye of the audience, as previously viewed frames of like images. This topic is the second area of novel capabilities of the inventive system and method the use of geo spatial depth grid points of reference.
- 3) By maintaining a consistent level of depth information on the screen, the audience is able to increasing perceive greater and greater degrees of depth detail, which results in a lowering of the mind’s censorship cues telling us that these images are not “real”. In 3D depth perspective, the greater the degree of depth realism, the higher the degree of 3D immersiveness, leading to an increase in the viewer’s emotional engagement—this inventive technique is referred to as “command frames.”
- 4) The audience needs to become accustomed to seeing everything in the frame in 3D, effortlessly. At that point the 3D cues which trigger depth perception, have formed the habit of seeing in 3D, as it is the natural way humans see, resulting in not seeing the non 3D visual cues, further intensifying the 3D impact. This novel development is based on using the layering technique of various commercial tools to enhance detail, sharper edge detection, and gray scale shading, creating a baseline 3D effect.
- 5) The overall intensity of the depth map image may alter dramatically between close up to wide shot, but the error correction of all the frames must be consistent, the general geospatial relationships, need to be consistent, and except where it is intentional that the image be driven to the edge for added impact, images should not be jarring in their incorrect juxtapositions to each other. If the effect of the depth perspective is to keep the viewer from “getting lost in the movie”, then the effect is counter productive. The novel technique designed to accomplish this goal, is the adjustment of the 3DF-3DVC system screen position control. This control is part of the 3DF-3DVC system set up, and its adjustment is made before the clip is processed. A correct setting should be identified for each segment of the clip requiring drastic visual changes, and only the frames which are best served by the recorded position of the screen placement control should be exported at that particular screen position setting.
- 6) If the purpose of the 3D effect is to provide an entertaining visual level of excitement, then the effects which support this high impact depth visuals comprise “over the top pop out of the front of the screen” image quality. There are a number of proprietary techniques which have been discovered in connection with the present invention to create such effect by way of example, one such technique involves creation of multiple layers of contrasting depth maps, on adjacent objects, thus forming a visual basis for comparison.
- 7) Sometimes it is necessary to create an exaggerated depth effect in order to define the image and focus the viewers’

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attention thereon. The means to accomplish this is utilization of the inventive “exaggerated depth mapped image” technique. This technique created an illusion of how a particular object is “expected” to look. It is more important that the images meet expectations, than be “correct”. In order to accomplish this, many times it is necessary to overstate the depth effect of an object in gray scale values—in order to get many of the objects to appear consistent with the other depth effects, it is necessary to “show-case” a number of objects to create the desired focus of visual attention.

Other image correction effects, that may be used in accordance with the various embodiments of the novel system **100** and the novel process **200** of the present invention, include, but are not limited to, the following:

Gray scale depth mapping correction on multiple planes,
Creating sharper edge detection layers for volume definition.

Layers for Command Frames.

Layers for Action Frames

Layers for Static frame backgrounds

Layers for perspective shading and volume

3D boxes for grid mapping

3DF-3DVC system front of screen positioning, relative to projection out of the screen layer, and mapping tricks for impact.

3DF-3DVC system special effects for creating compromise image effects without losing definition.

3D Histogram adjustments.

As a result, in view of all of the above, the use of various embodiments of the inventive system and method (or of portions thereof), enables companies to offer, and consumers and other end-user parties to experience, 3D content media in a very cost-effective and efficient manner, thus overcoming the flaws and drawbacks of all prior 3D-related offerings that served as barriers to the well-deserved success of the 3D media experience market, and making inexpensive and ready availability of the “3D experience” a reality.

Thus, while there have been shown and described and pointed out fundamental novel features of the inventive system and method as applied to preferred embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices and methods illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

We claim:

1. A method, implemented in at least one data processing system, for improving the efficiency, quality, viewing comfort and/or visual impact of a 3D experience capable of being provided to at least one viewer of a 3D content media comprising a plurality of content sections, in conjunction with the use of at least a portion of a plurality of predetermined 3D content modification techniques, the method comprising the steps of:

(a) identifying at least one content section of the 3D content media comprising at least one 3D media element and selecting at least one corresponding predefined plural 3D content modification technique that is configured for provision of optimum improvement of the 3D experience when applied thereto;

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(b) for each said selected at least one predefined plural 3D content modification technique configured for then-current application to said corresponding at least one 3D media element, applying said selected at least one predefined plural then-current 3D content modification technique thereto;

(c) for each said selected at least one predefined plural 3D content modification technique configured for future application to said corresponding at least one 3D media element, determining a setting for at least one parameter of said selected at least one predefined plural future 3D content modification technique, optimal for application to said corresponding at least one 3D media element;

(d) associating a reference to said selected at least one predefined plural future 3D content modification technique and said determined at least one optimal parameter, with said corresponding at least one 3D media element;

(e) selectively repeating said steps (a), (b), (c) and (d) for at least one additional section of the 3D content media;

(f) enabling an operator to view results of said steps (a), (b), (c) (d), and (e), and to at least one of: selectively cancel at least one result of at least one operation previously performed at least one of said steps (a), (b), (c), (d), and (e), and selectively change at least one operation previously performed at least one of said steps (a), (b), (c), (d), and (e), to an alternate operation selected by the operator;

(g) after conclusion of said step (f), generating a dynamic 3D content media container file configured for playback to at least one viewer utilizing at least one 3D content playback system operable to apply said selected at least one predefined plural future 3D content modification technique to said corresponding at least one 3D media element in accordance with said at least determined at least one optimal parameter, and further configured to store, for each 3D content media element identified at said step (a), at least one of:

at least one immediate 3D content modification applied at said step (b), and

at least one said associated reference to said at least one corresponding predefined plural future 3D content modification technique, and said determined at least one optimal parameter therefor;

such that said dynamic 3D content media container file comprises 3D media content having at least one modified content section each comprising at least one modification specifically optimal for application thereto, thereby maximizing the efficiency, quality, viewing comfort and/or visual impact of the 3D experience being provided to viewers thereof during playback.

2. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein the 3D content media comprises at least one of: stereoscopic 3D content, and auto-stereoscopic 3D content.

3. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein the 3D content media comprises at least one of: first 3D content media previously captured by at least one 3D content capture system, second 3D content media previously generated by at least one 3D content source, third 3D content media previously converted, by a 3D content capture system, from captured 2D media content, and fourth 3D content media previously converted, by a 3D content source, from previously generated 2D content.

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4. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein said at least one content section of the 3D content media, identified at said step (a), comprises a plurality of content frames comprising said at least one 3D media element.

5. The method of claim 4, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein said predefined plural content frames comprise a corresponding scene, and wherein each said at least one 3D media element comprises at least one of: a static 3D displayed object, and a moving 3D displayed object.

6. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein at least one of said steps (a), (b), (c), (d) and (e), is performed by the at least one data processing system under manual control of an operator.

7. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein said at least one 3D content playback system comprises at least one of: a 3D content media player operable to process said dynamic 3D content media container file for playback by generating therefrom and transmitting a 3D content output signal to a corresponding connected 3D content display system, and a 3D content display system operable to process said dynamic 3D content media container file for playback by generating therefrom, and displaying said 3D content output signal.

8. The method of claim 7, wherein said at least one 3D content playback system is operable to apply each said at least one predefined plural future 3D content modification technique to said corresponding at least one 3D media element of said 3D content media, in accordance with said at least one optimal parameter therefor, further comprising the steps of:

(h) providing said dynamic 3D content media container file, generated at said step (f), to said at least one 3D content playback system;

(i) identifying, by said at least one 3D content playback system in said dynamic 3D content media container file, at least one said associated reference to said at least one corresponding predefined plural future 3D content modification technique, and said determined at least one optimal parameter therefor; and

(j) applying said at least one referenced corresponding predefined plural future 3D content modification technique to said corresponding at least one 3D media element of said 3D content media, in accordance with said at least one optimal parameter therefor.

9. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein said plurality of predetermined 3D content modification techniques further comprises a plurality of content modification techniques operable to optimize at least one additional visual characteristic of 3D content media, further comprising the steps of, prior to said step (e):

(k) identifying at least one content section of the 3D content media comprising at least one visual characteristic, and selecting at least one corresponding predefined plural content modification technique that is configured for provision of optimum improvement of the 3D experience when applied thereto; and

(l) for each said selected at least one predefined plural content modification technique configured for immediate application to said corresponding at least one content section, applying said selected at least one predefined plural immediate content modification technique thereto.

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10. The method of claim 9, wherein said step (e) further comprises the step of:

(m) selectively repeating said steps (k) and (l) for at least one additional section of the 3D content media.

11. The method of claim 9, further comprising the steps of, 5
after said step (k) and prior to said step (e):

(n) for each said selected at least one predefined plural content modification technique configured for future application to said corresponding at least one content section, determining a setting for at least one parameter of said selected at least one predefined plural future content modification technique, optimal for application to said corresponding at least one content section; and 10

(o) associating a reference to said selected at least one predefined plural future content modification technique and said determined at least one optimal parameter, with said corresponding at least one content section. 15

12. The method of claim 11, wherein said step (e) further comprises the step of:

(p) selectively repeating said steps (n) and (o) for at least one additional section of the 3D content media. 20

13. The method of claim 11, wherein said at least one 3D content playback system is operable to apply said at least one corresponding predefined plural future content modification technique to at least one predetermined content section of said 3D content media, in accordance with said at least one optimal parameter therefor, further comprising the steps of: 25

(q) providing said dynamic 3D content media container file, generated at said step (f), to said at least one 3D content playback system;

(r) identifying, by said at least one 3D content playback system in said dynamic 3D content media container file, at least one said associated reference to said at least one corresponding predefined plural future content modification technique, and said determined at least one optimal parameter therefor; and 30

(s) applying said at least one referenced corresponding predefined plural future content modification technique to at least one predetermined content section of said 3D content media, in accordance with said at least one optimal parameter therefor. 35

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14. The method of claim 13, wherein said step (q) comprises the step of:

(t) streaming said dynamic 3D content media container file, generated at said step (f), to said at least one 3D content playback system from a remote 3D content source.

15. The method of claim 13, wherein said dynamic 3D content media container file is stored on physical media operable to store 3D content media container files, and wherein step (q) comprises the step of:

(u) transmitting said dynamic 3D content media container file, generated at said step (f), to said at least one 3D content playback system from said corresponding physical media. 15

16. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein the at least one data processing system operable to perform said steps (a), (b), (c), (d), and (e), is connected to said at least one 3D content playback system.

17. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein said at least one 3D content playback system comprises the at least one data processing system operable to perform said steps (a), (b), (c), (d), and (e).

18. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein the at least one data processing system is operable to perform said steps (a), (b), (c), (d), (e), and (f), prior to playback of said dynamic 3D content media container file, further comprising the step of: 25

(v) after said step (f), storing said dynamic 3D content media container file, on physical media operable to store 3D content media container files, for later playback by said at least one 3D content playback system. 30

19. The method of claim 1, for improving the efficiency, quality, viewing comfort, and/or visual impact of the 3D experience, wherein the at least one data processing system is operable to perform said steps (a), (b), (c), (d), (e), and (f), in conjunction with playback of said dynamic 3D content media container file by said at least one 3D content playback system. 35

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